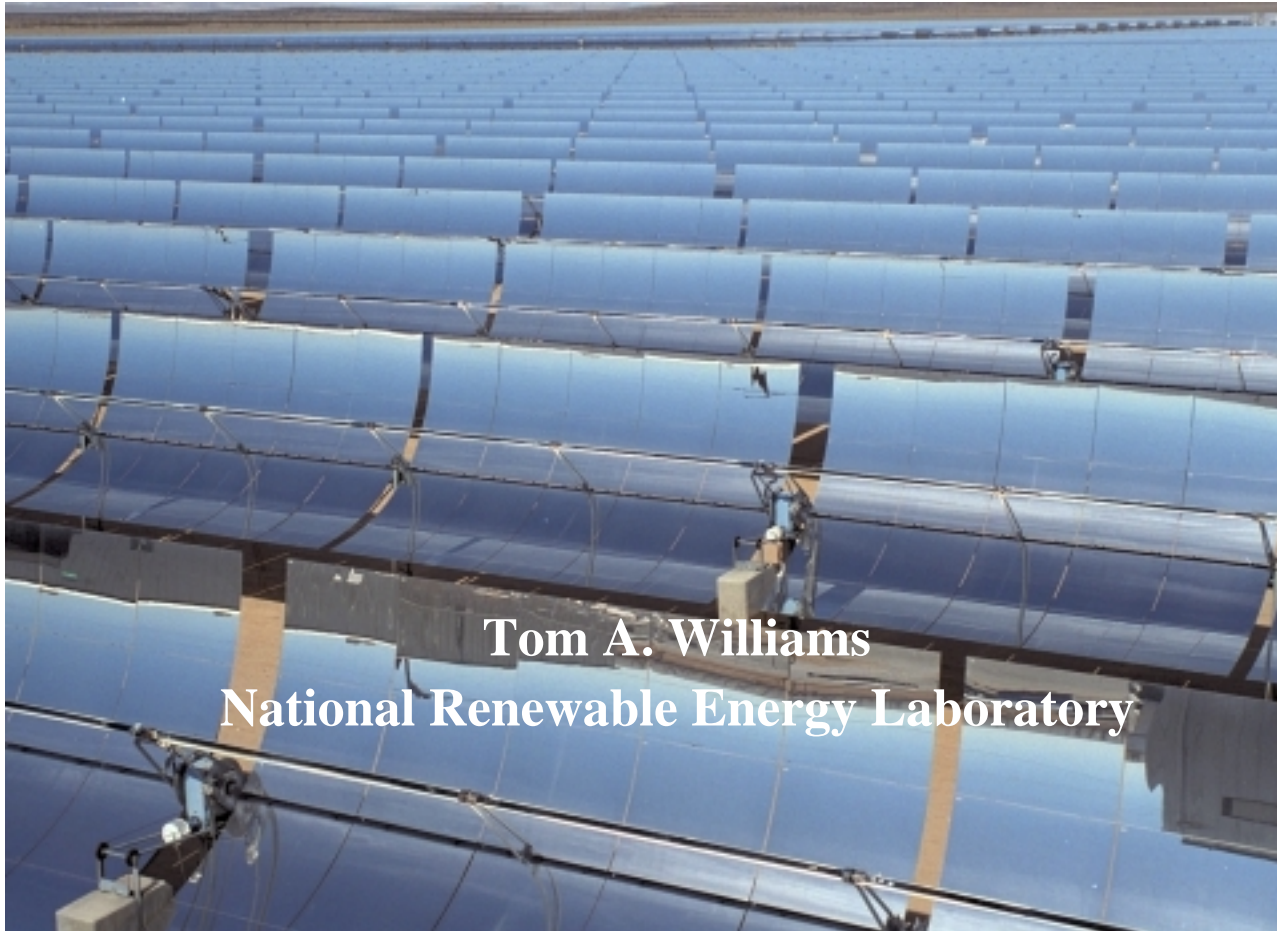


Overview of Concentrating Solar Power



Tom A. Williams
National Renewable Energy Laboratory



Concentrating Solar Power

Sun♦Lab

Sandia National Laboratories, Albuquerque, NM
National Renewable Energy Laboratory, Golden CO

Concentrating Solar Power (CSP) Technologies

- Concentrate sunlight by 80-3000 times to produce high temperature heat
- Heat converted to electricity
 - steam turbine
 - gas turbine
 - Stirling Engine
- Size range from
< 10 kWe to 200 MWe



Concentrating Solar Power

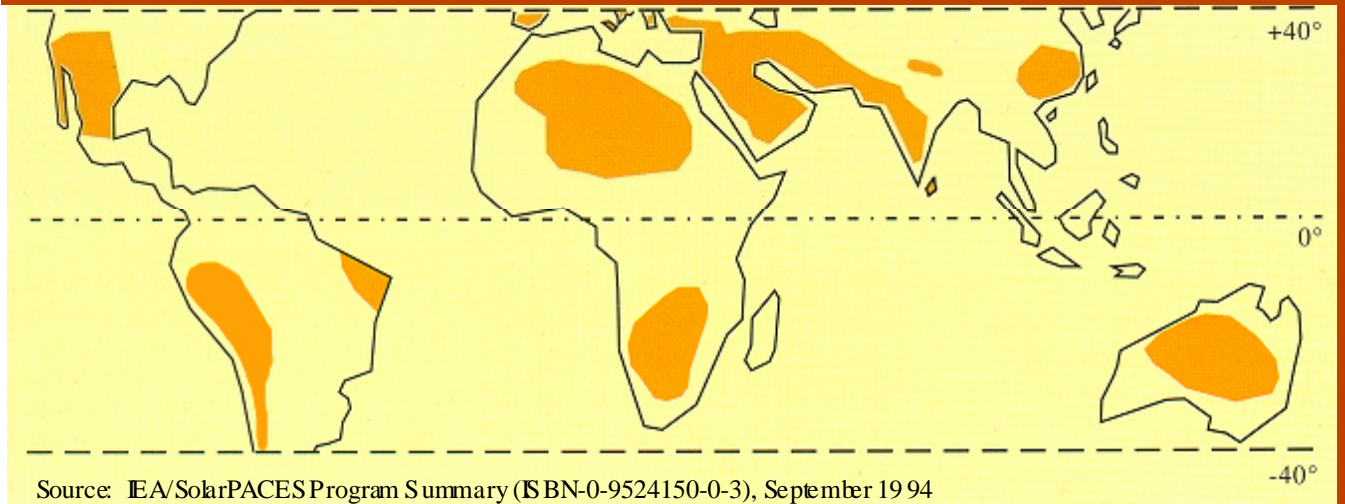
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Characteristics of Concentrating Solar Power

- Low environmental impacts
- Large, renewable resource
- Fuel diversity
- Strategic Resource
- Job Creation

Areas with Average Direct Normal Solar Radiation ³ 5.0 kWh/m²/day



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Key Attributes of Solar Thermal Electric Technologies

- Proven reliability with 100 plant-years of on-grid experience
- Demonstrated dispatchability provides high-value power
- High annual efficiencies
- Easy integration into conventional grid
 - operates like a fossil plant
 - familiar energy conversion systems
 - hybrid solar/fossil plants



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Grid Connect Technologies

Trough



Power Tower

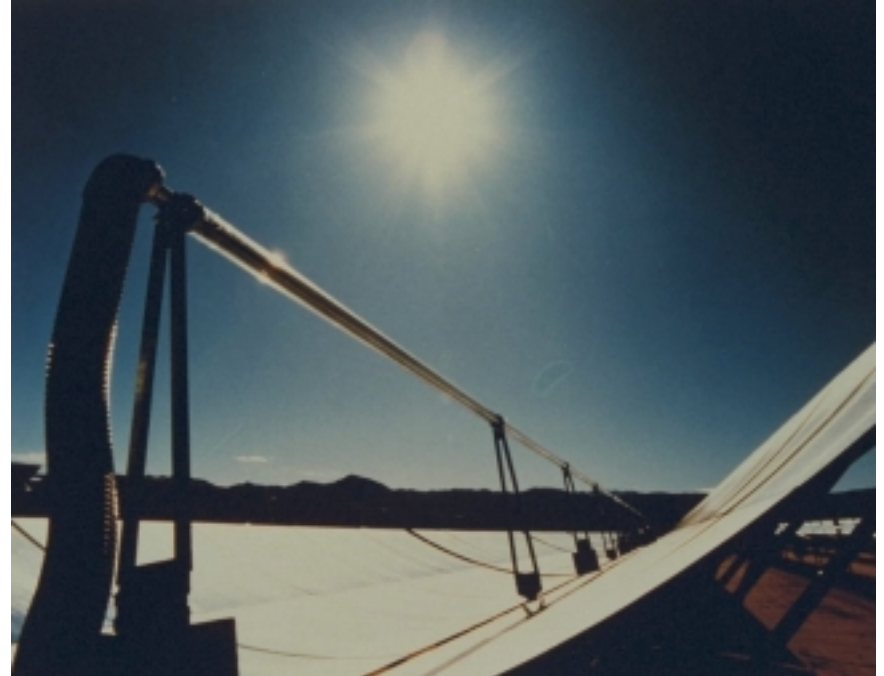
Distributed Power Systems



Dish

Trough Systems

- Proven reliability in commercial systems with 100 plant-years of operation
- 354 MWe installed capacity in California
- Achieves dispatchability by hybrid operations with gas
 - thermal energy storage an option

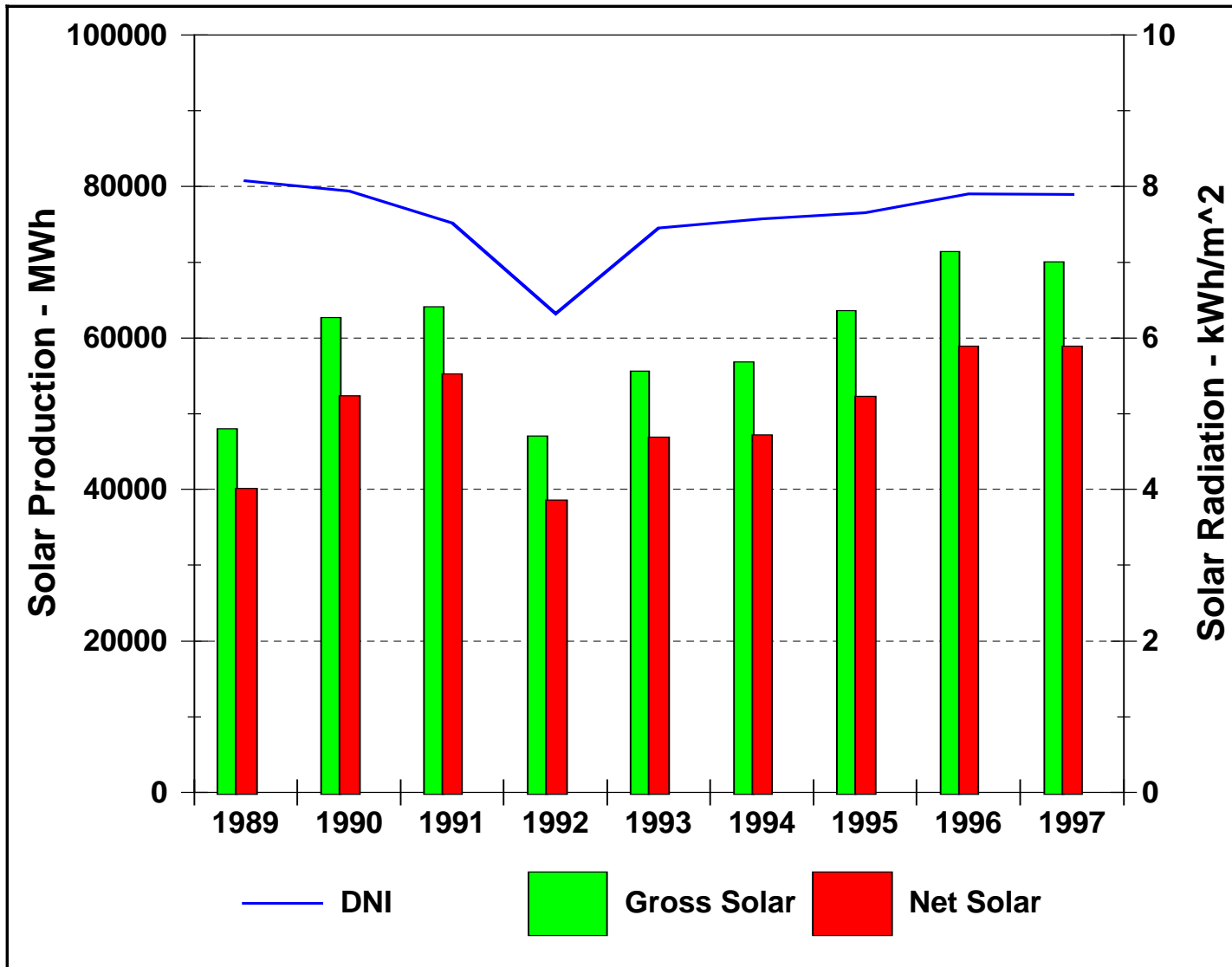


Costs

Current \$0.10-.14/kWh

Future \$0.04-.06/kWh

SEGS VI Historical Performance



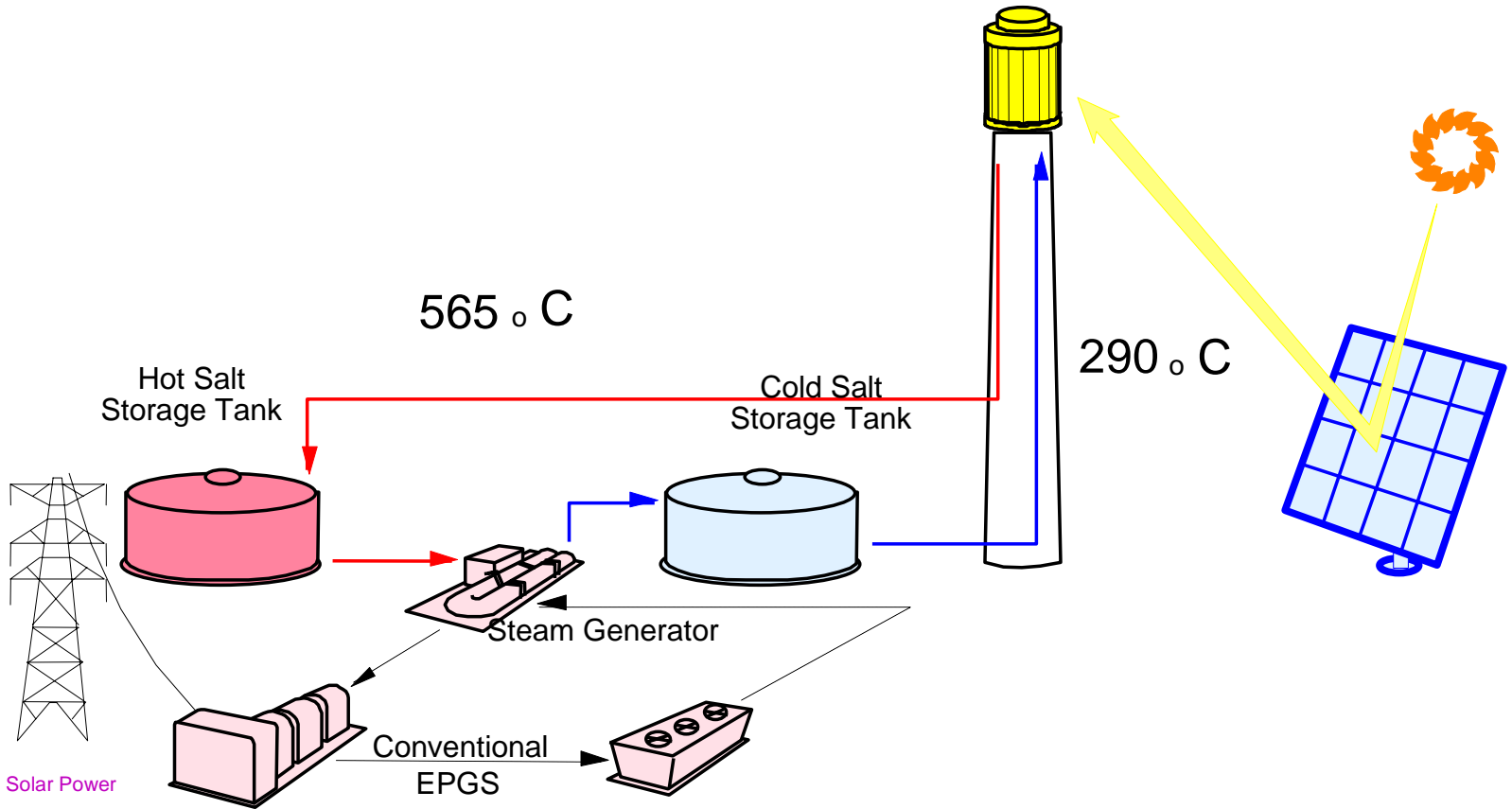
Power Tower Systems

- Developed and demonstrated in pilot-scale systems
- Deployable in sizes from 30-200 MW for dispatchable power generation
- Option for low-cost thermal energy storage
- Easily integrated in hybrid plants
- Projected to be lowest cost large scale CSP systems



**The 10 MWe Solar Two Pilot Plant
operated from 1996-1999**

Solar Two Schematic



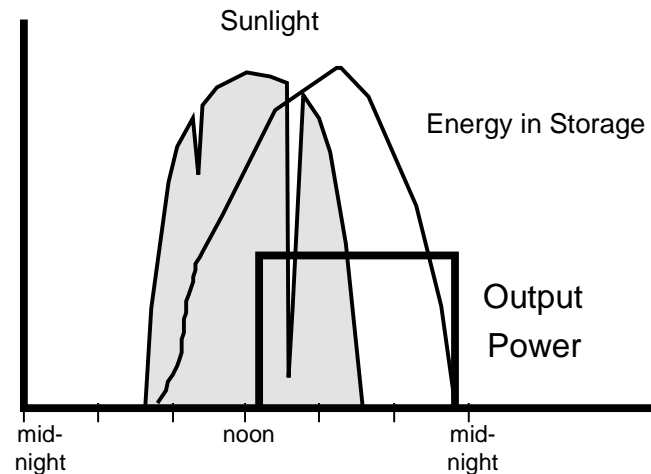
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Solar Two Accomplishments

- Simulate design and operation of commercial scale plant
- Validate technical characteristics
- Improved accuracy of cost and performance projections
- Technology transfer



Solar Two demonstrated efficient and cost-effective storage of solar energy

Modular Technology

- highest efficiency solar technology demonstrated (29% solar-electric)
- Modular 5-25 kWe units
- Cost competitive with diesel generators
- Unattended operation
- Can burn fossil fuel for night time operation
- Applications: remote village electrification, water pumping, remote grid
- Developmental stage



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Technical Status



- Tens of thousands of hours operating time on dish engine systems
- Predictable performance
- High availability in test systems
- Reliability improvements and O&M reduction an area for future enhancement
- Energy cost potential of \$0.05/kWh



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Conclusions

- Concentrating Solar Power is reliable and demonstrated in large-scale commercial systems
- While costs are still high for widespread deployment, significant cost reductions can be achieved
- Numerous attractive features for future deployment in sunbelt regions of the world